

THE DESIGN OF MILITARY BASE ENTRANCE AND THE USE OF ANSYS AUTODYN SOFTWARE WITHIN THE SIMULATION OF THE BLAST WAVE SPREADING

Abstract

In the time of unconventional warfare, force protection is one of *the highest priorities of every army*. Engineers mainly deals the personnel and structures protection against large number of explosions caused by enemy's attempts to destroy important parts of military base and to cause huge human casualties. Protective solutions realized within protective structures are mainly based on practical experience with explosions effects. As a preventive measure, the simulation software can be used as assumption for the optimal design of important parts of the military base and thereby to prevent massive loss of lives and equipment.

Keywords: Entry Control Point, Vehicle Born Improvised Explosive Device, blast wave, pressure, military base.

INTRODUCTION

Entry Control Point (ECP) is one of the most important parts of perimeter, which is surrounding the military base. Every person and car going to the base has to go through this point. For this reason there is high requirement to propose it properly and also built from appropriate materials. The failure to comply main principles should lead to the massive loss of humans, weapons and other stuff.

In the time of Operation Iraqi Freedom during years 2003 – 2011 there were a lot of attacks aimed to the ECP carried out by Vehicle Born Improvised Explosive Device (VBIED). These attacks were mainly done to pierce the entrance and to explode inside the base. With a car fully loaded with the explosion there was higher probability to kill more soldiers at the base than to eliminate them with a standard way of fighting. The attacks are also frequently performed with suicide bombers using a lot of different kinds of Improvised Explosive Device (IED). Highly sophisticated system of ECP security can considerably assists to the defense of military base and enable the soldiers to feel safe.

Despite all this barriers the enemies can overcome ECP and initiate the VBIED. With the blast of such big quantity of explosives there is formed large blast wave which crucially destroys humans and material at the base. The knowledge of the blast wave spreading and its size are important for a better arrangement of ECP and also to improve the protection of the base. For this reason there is need to know, how the blast wave will spread at the entrance.

To detect the effects of blast wave is effectively used the software from ANSYS Inc. The article is focused on the design of military base entrance and on the use of software such as ANSYS Workbench platform and ANSYS AUTODYN as a software, which is supplied as an integral part of the ANSYS Workbench environment.

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Fig. 1 Soldiers get familiar with their surroundings at Entry Control Point 14 at Victory Base Complex, Iraq. [1]

THE DESIGN OF MILITARY BASE ENTRANCE

The ECP zones

Approaching zone creates the interface between local road network and the military base. It should contain some construction elements – obstacles, which are determined for the following functions:

- to lower the speed;
- to classify the vehicles according to the types;
- enables the verification of an entry;
- enables to keep adequate distance between vehicles;
- enables to give first warning to suspicious people and vehicles. It is also possible to see the attempts to leave allowed routes.



Fig. 2 Approaching zone at the camp Šajkovac, Kosovo [2]

Entry control zone is the main part of ECP. It contains the post of guardians, place for checking cars and persons and some equipment used by security units.

This zone should be equipped with stuff specific following functions:

- verification of persons;
- complete control of the vehicles and persons;
- visit inspection;
- checking the approaching zone;
- to regulate the speed of entering and leaving vehicles.



Fig. 3 US Air Force Staff Sergeant from 86th Contingency Response Group and his military working dog are checking a vehicle for explosives during Operation IRAQI FREEDOM [3]

Zone of reaction is created by the boundary from the end of entry control zone to the last barrier or gate of the base. It also creates the boundary of ECP's area and should be designed to reach these functions:

- to allow the reactions to the threats;
- to provide the necessary reaction time;
- to activate last barrier or close the gate;
- to ensure visual inspection of all the ECP space.



Fig. 4 Zone of reaction at the camp Šajkovac, Kosovo [4]

Safe zone is created by active and passive barriers in all the directions, which protects the ECP area against the explosions. The size of this zone is adapted by the evaluations of danger (assumed weight of explosion). If the safe zone is not possible to be big enough to ensure the space without possible threat, it must be reviewed other options and decisions about other measures against the risks.



Fig. 5 Safe zone at AL-RASHEED army base, Iraq [5]

The organization of ECP

The deployment of ECP must be in accordance with the whole military base. It must be provided according to these demands:

- **Safety:** The main priority of the ECP is to ensure the perimeter of military base. The ECP must be built with security equipment, which is performed to stop VBIED and also people not allowed to access the base. For these tasks ECP must be created like:
 - easy access point;
 - to increase the level of defense and to decrease the risks in the way of thorough checking control;
 - to fulfill the protection against terroristic threats;
 - to be functional if all the demands will be complied. [6]
- **Protection:** ECP must be maintained as the working environment according to the norms, which is reliable and comfortable for guarding units. Special attention must be paid to climatic conditions and location, in which the ECP is. [6]
- **Capacity:** ECP must ensure continuous and fluent cars traffic and to avoid slowdown of the cars and humans. This fact is very hazardous in the sense of a quick reaction to a possible danger. [6]
- **Overall impression:** The whole design of ECP must be done properly according to the good feeling of providing professional protection to all soldiers at the military base. This fact is very important in the sense of positive feeling of safety and it is so obvious for seamless duties. [6]

THE SIMULATION OF THE BLAST WAVE

Despite all security measures dedicated to the design of ECP, there were some serious cases of the car driven by the suicide bomber that had passed through entering control zone and got in the internal structure of the base. The explosion of such a VBIED is characterized by the huge blast wave, which represent enormous threat to the people and buildings. For this reason,

the characteristic of blast wave must be known and the ECP has to be structurally modified to eliminate the effects of it.

Blast wave is rapidly spreading wave of compressed air in the atmosphere characterized by a gradual change in pressure, density and temperature. Usually it is created and started by the explosion. The trajectory of spreading is in the direction from epicenter of explosion. If the environment is continual, than the speed of the blast wave is the same in each direction.

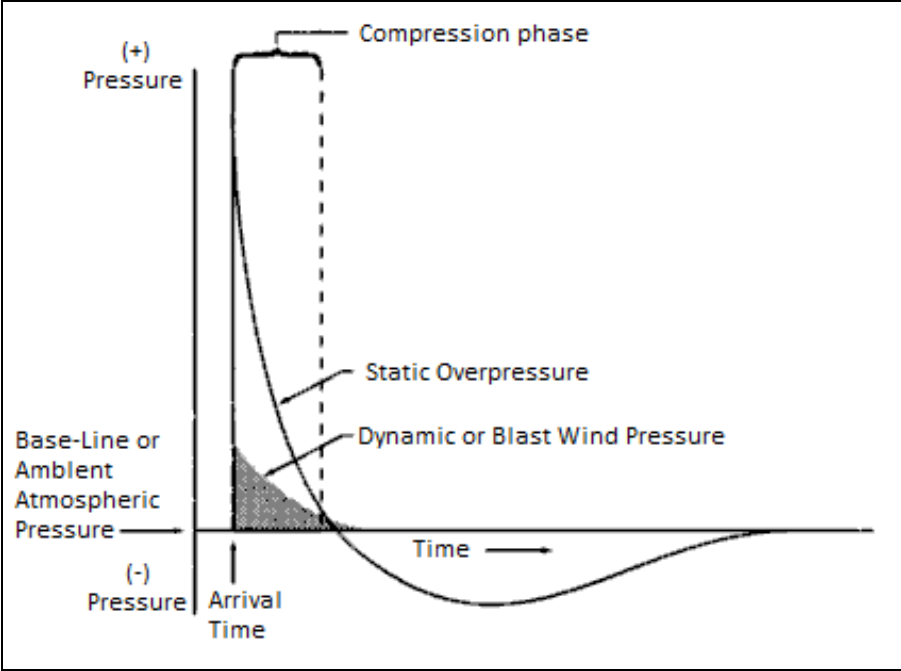


Fig. 6 Variations of Static Overpressure and Dynamic Pressure with Time [7]

When a blast wave strikes the surface of a hard target, such as a building, the reflected wave will reinforce the incident wave, and the face of the building will be subjected to overpressures 2 to 8 times that of the incident wave alone. The severity of this additional stress depends on many factors, including the peak overpressure of the incident blast wave, as well as the angle at which the wave strikes the building. As the shock front advances, it bends or diffracts around the building, and the pressure on the front wall decreases rapidly. [7]

However, during the brief interval in which the blast wave has not yet engulfed the entire structure, a considerable pressure gradient exists from front to rear that places a severe stress on the building. For small objects, this period of so-called diffraction loading is so small that no significant stress is encountered. For large buildings, however, the stress of diffraction loading will be considerable. Even after the shock front has passed across the building, the structure will still be subjected to a severe compression force and to severe drag forces from the transient winds. The actual overpressures required to produce severe damage to diffraction sensitive targets are actually quite low. [7]

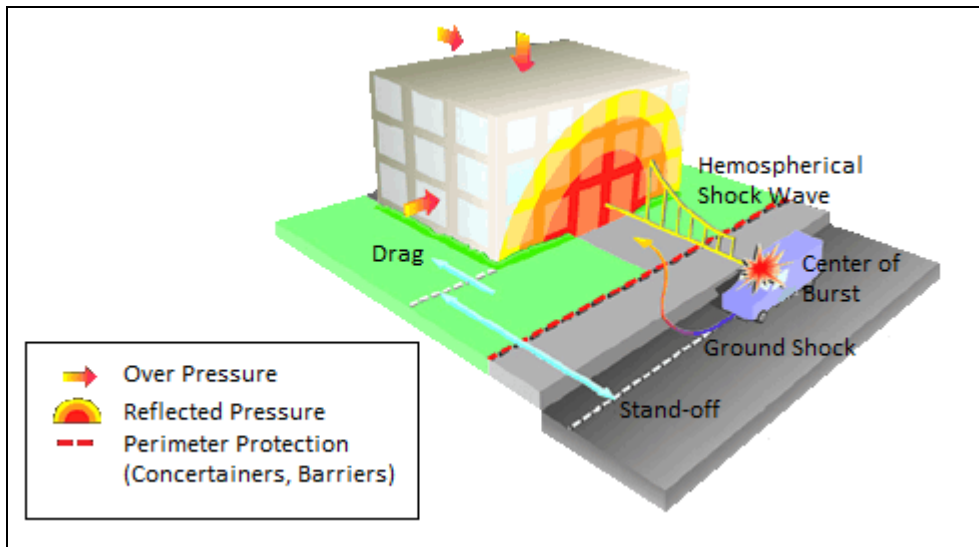


Fig. 7 The effects of the explosion close to the structure caused by VBIED [8]

For the purposes of the blast wave characteristics, its size and spread in different environments, there is convenient possibility to use the software from ANSYS Inc.

ANSYS WORKBENCH

The ANSYS Workbench platform is the framework upon which the industry's broadest and deepest suite of advanced engineering simulation technology is built. An innovative project schematic view ties together the entire simulation process, guiding the user through even complex multi-physics analyses with drag-and-drop simplicity.

With bi-directional CAD connectivity, powerful highly-automated meshing, a project-level update mechanism, pervasive parameter management and integrated optimization tools, the ANSYS Workbench platform delivers unprecedented productivity, enabling Simulation Driven Product Development. [9]

Typical tasks you can perform in Workbench are:

- Creating models using DesignModeler or importing models from a variety of CAD systems.
- Generating a numerical mesh suitable for a variety of FE and CFD methods using Meshing or Advanced Meshing
- Performing implicit finite element analyses using Simulation for structural, thermal, and electromagnetic simulations.
- Performing explicit transient nonlinear dynamics simulations of solids, fluids, gases, and their interaction using ANSYS AUTODYN
- Optimizing designs using DesignXplorer or DesignXplorer VT, and implementing a chosen design back into the original model [10]

ANSYS AUTODYN

ANSYS AUTODYN is an explicit analysis tool for modeling nonlinear dynamics of solids, fluids, gas, and their interaction.

With a fully integrated, easy to use graphical interface allowing set up, running, and post processing of problems, ANSYS AUTODYN offers:

- Finite elements (FE) solvers for computational structural dynamics;
- Finite volume solvers for fast transient Computational Fluid Dynamics (CFD);
- Mesh-free particle solvers for high velocities, large deformation, and fragmentation (Smoothed-particle hydrodynamic - SPH);
- Multi-solver coupling for multi-physics solutions including coupling between FE, CFD and SPH;
- A wide suite of materials models incorporating constitutive response and coupled thermodynamics;
- Serial and parallel computation on shared and distributed memory systems. [11]

ANSYS AUTODYN has been used in a vast array of projects and nonlinear phenomena. It is also possible to use it effectively for building protection measures and insurance risk assessment for blast effects in military bases.

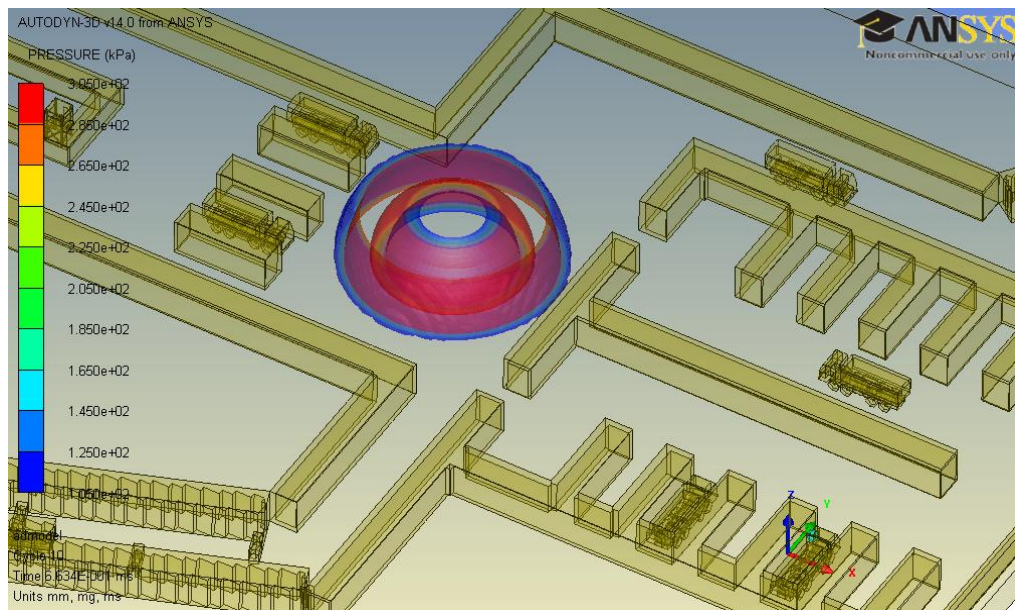


Fig. 8 The explosion of a 1000 kg of TNT between control zone and parking in the time of 6 ms...¹

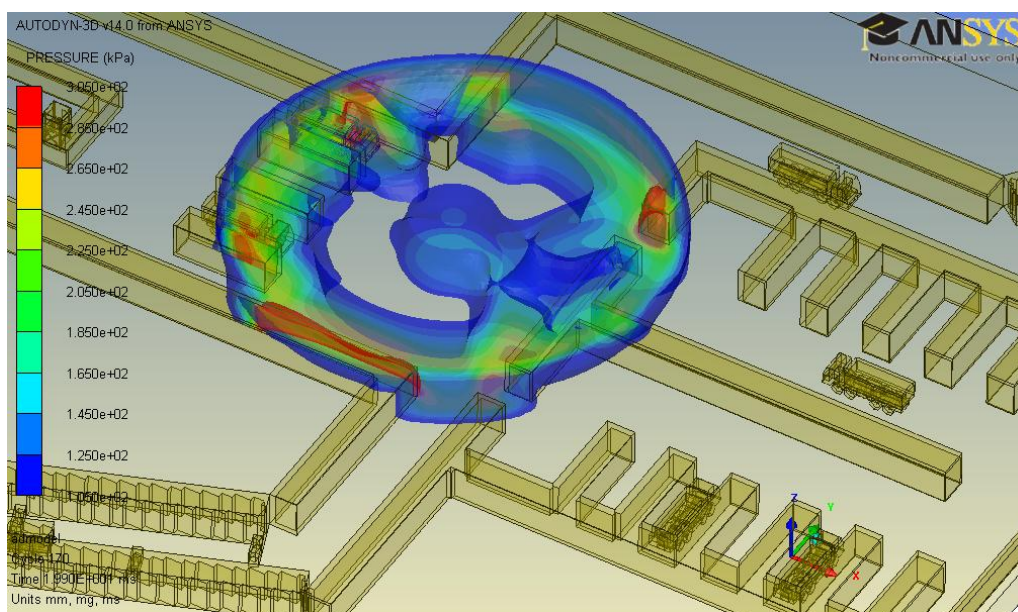


Fig. 9 ... and in the time of 20 ms. 2

CONCLUSION

Terrorist threat is achieved by continual attacks, which are aimed to the military bases and realized by huge load of explosives placed in VBIED. The article is aimed to familiarize the reader with the characteristic of ECP, its structure and design. Next part is dedicated to the characteristic of the blast wave, its spreading in the air and possibilities of ANSYS AUTODYN software which is used to evaluate the explosions.

With the knowledge of spreading the blast wave it is easier to design the main parts of military base like entrance, headquarter, ammunition depot etc. It is necessary to understand that all the soldiers are serving in hostile conditions for several months. For this reason the defense of military bases should be one of the highest priorities of every army.

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